OCTOBER 2019

WIM #42
US 61,
MP 119.6
COTTAGE GROVE, MINNESOTA

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #42 is located on US 61 near Cottage Grove in Washington county.

System Operation

WIM #42 was operational for the entire month of October 2019. Volume was computed using all monthly data.

System Calibration

WIM #42 was most recently calibrated on 2019-05-13. Table 1 summarizes the front axle weights of class 9s by lane [1]. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 1127204 | Passenger Vehicles: 1073024 | Heavy Commercial Vehicles: 54180

Monthly Average Daily Traffic (MADT): 36288 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 1748

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. NB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Tuesdays. SB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Sundays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), NB PVs generally reached peak volume levels between 03 PM and 05 PM. Similarly, SB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 03 PM and 05 PM, while volume going SB peaked between 03 PM and 05 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 54180 HCVs, 6780 of them were overweight [3]. These overweight HCVs contributed to 0.6% of total monthly volume, and 13% of total monthly

HCV volume. NB overweight vehicles typically reached highest numbers on Thursdays, with lowest volumes reported on Sundays. SB overweight vehicles tended to reach highest volumes on Wednesdays, with lowest volumes reported on Saturdays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 73.6% of all overweight vehicles traveling SB this month (see Figure 7 & 8).
Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in June.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,157 NB vehicles exceeded 88,000 pounds (99 vehicles were Class 9's; 31 vehicles were Class 10's). Of vehicles traveling SB,

581 NB vehicles exceeded 88,000 pounds (352 vehicles were Class 9's; 135 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from October 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in October 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling NB, while there were more empty Class 9's than fully_loaded traveling SB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the NB direction. In the SB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 373267 tons of freight was recorded to have crossed the WIM. More freight was shipped SB (58.9%) than NB (41.1%). See Table 4 and Figure 11 for more freight information.

####**Infrastructure Considerations Bridge.** Bridge No. 5895 (Hastings Bridge) is approximately 1.9 miles south of WIM #42, and Bridge No. 82J16 is 1.0 miles north of WIM #42. WIM #42 recorded a total of 1127204 vehicles with a combined GVW of 6695761 kips (1 kip = 1,000 pounds = 0.5 tons) in October 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 35845 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 62.5% of all ESALs were recorded SB while 37.5% was observed NB. In particular, 60% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 16% of total GVW observed this month). See Table 6 and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

#####WIM monthly reports can be found at:
http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html MnDOT's vehicle

classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

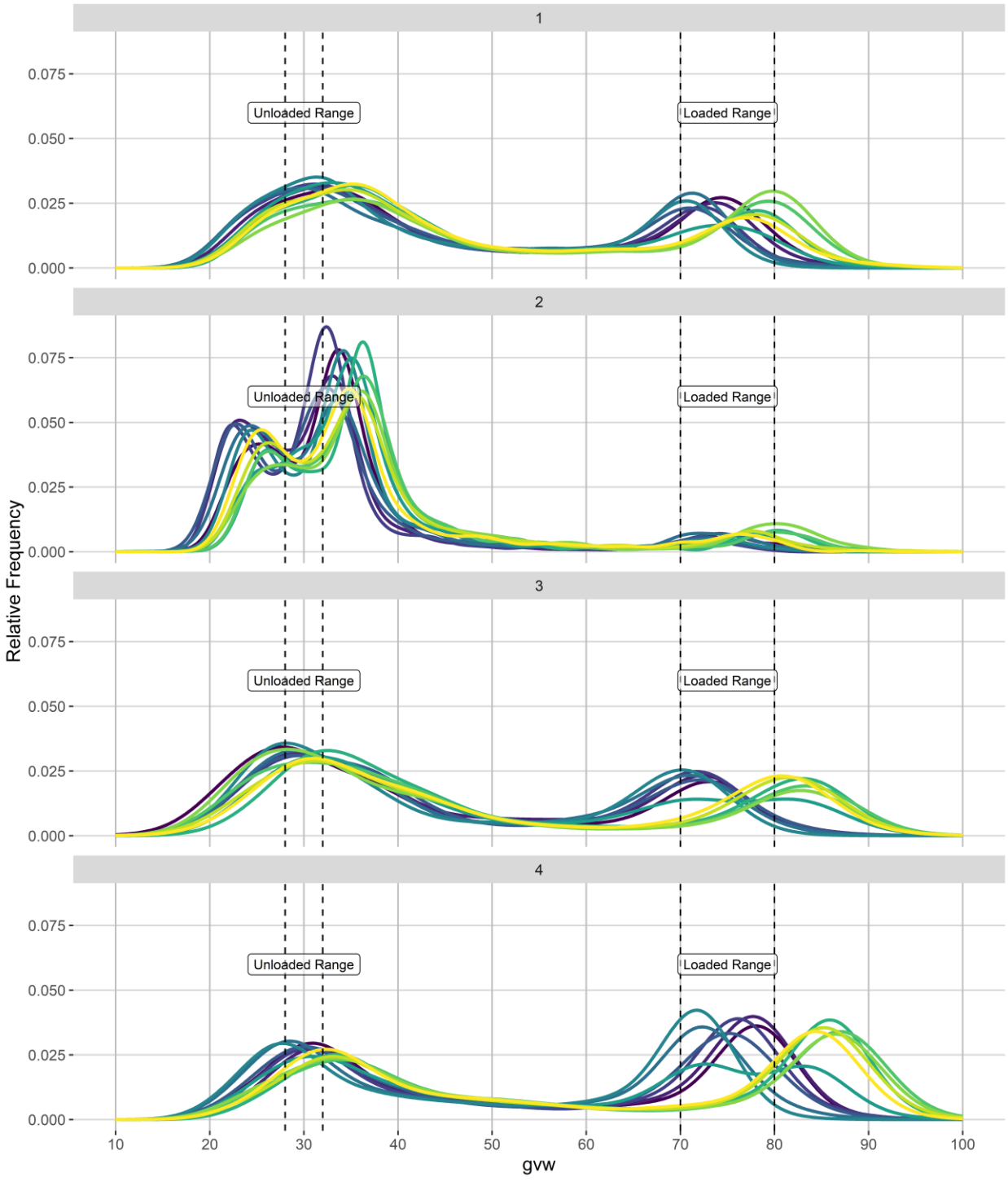
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

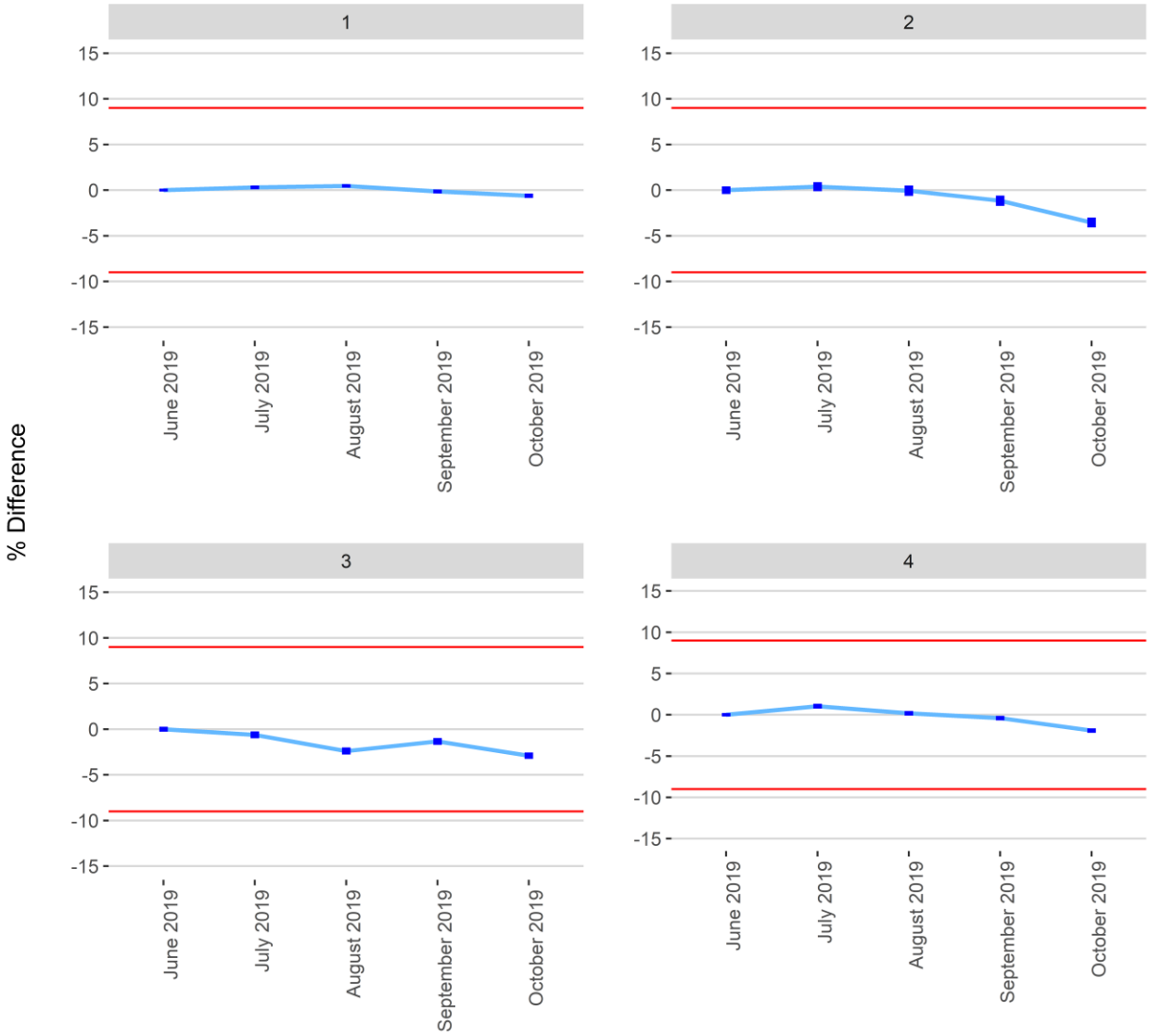
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume
vs. Day of the Week

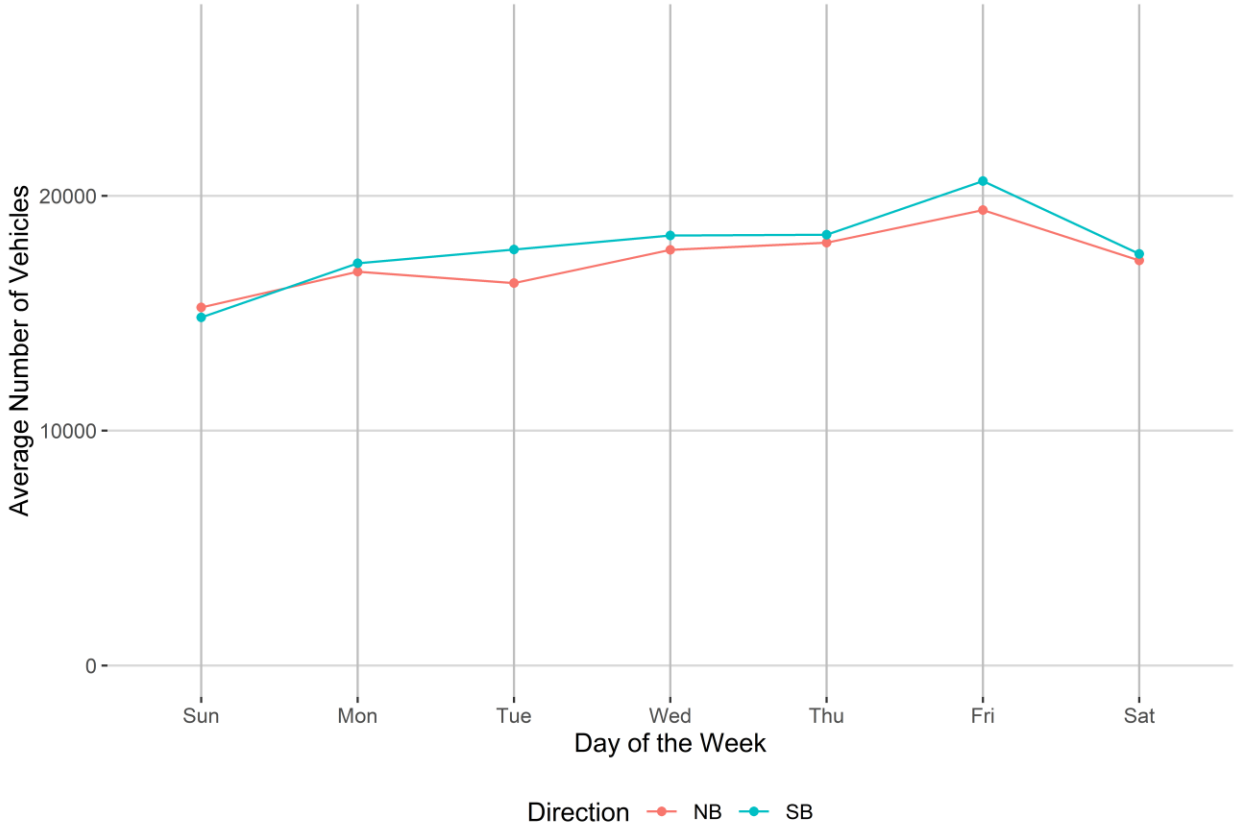


Figure 3 - Average Overweight Vehicle Volume
vs. Day of the Week

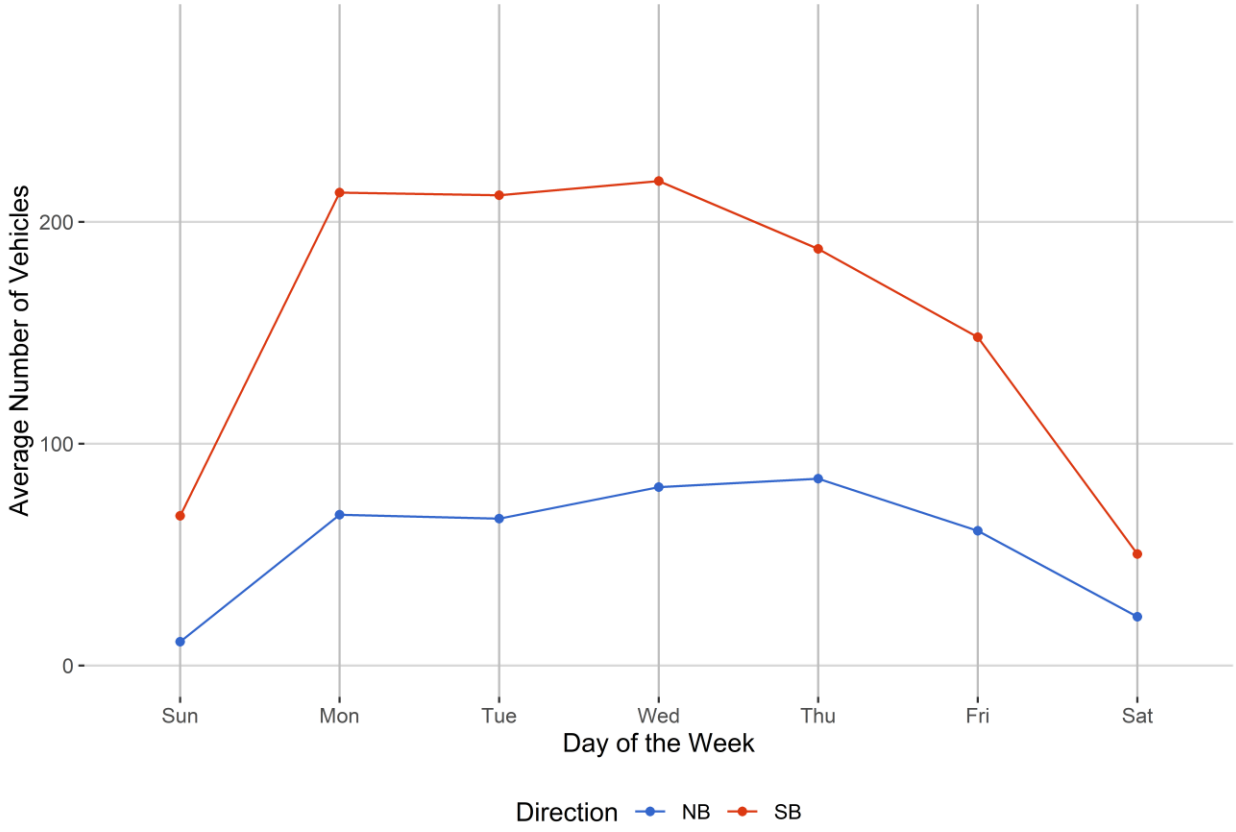


Figure 4 - Passenger Vehicles
vs. Hour of the Day

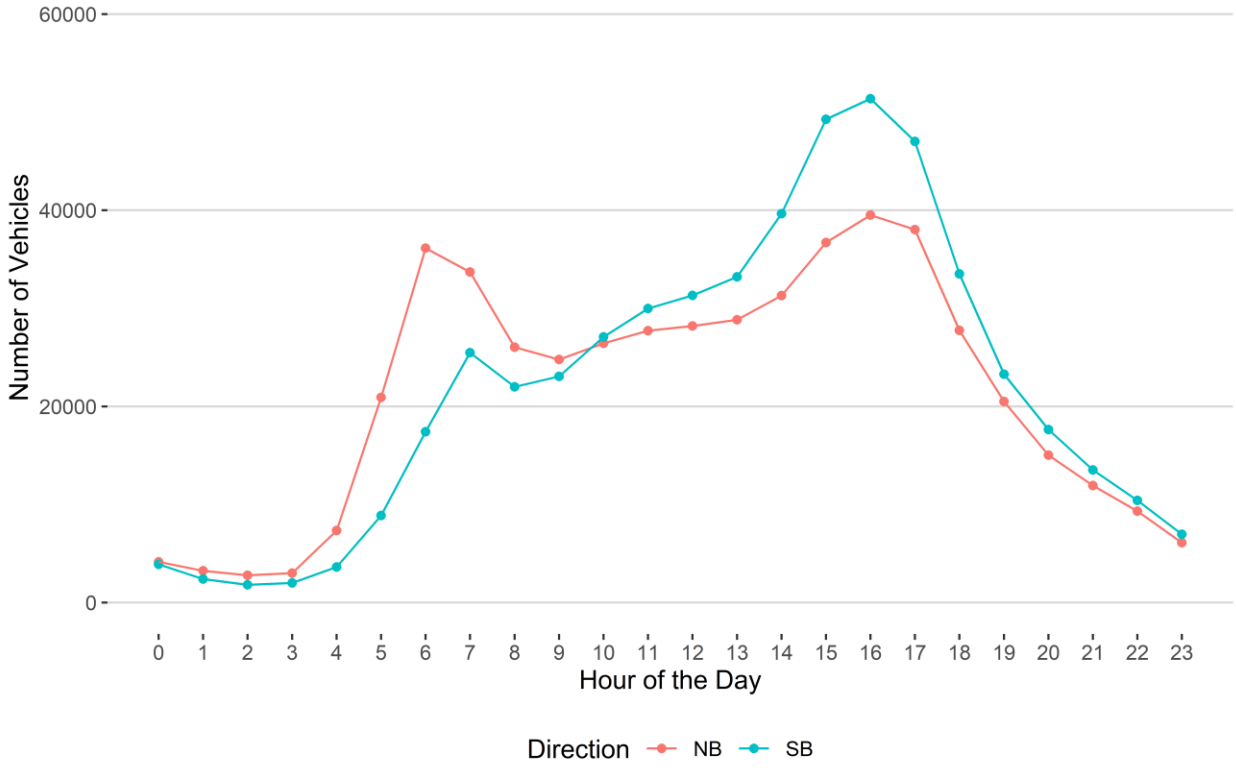


Figure 5 - Heavy Commercial Vehicles
vs. Hour of the Day

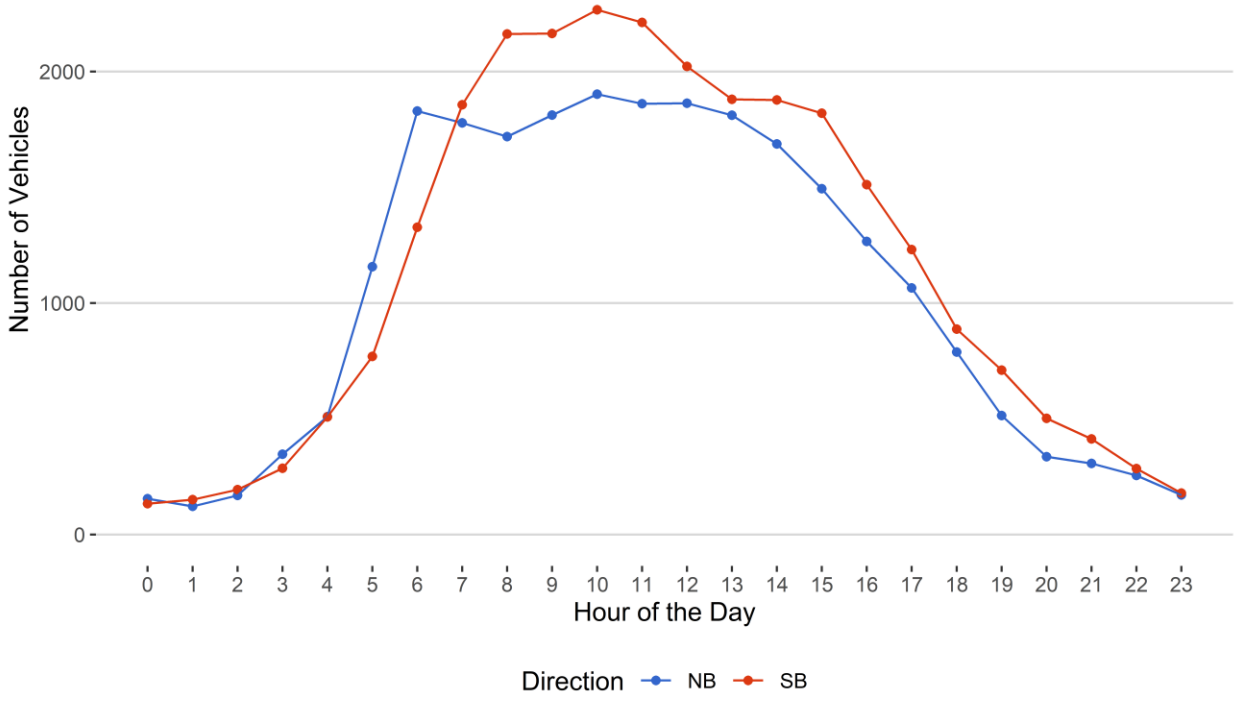


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

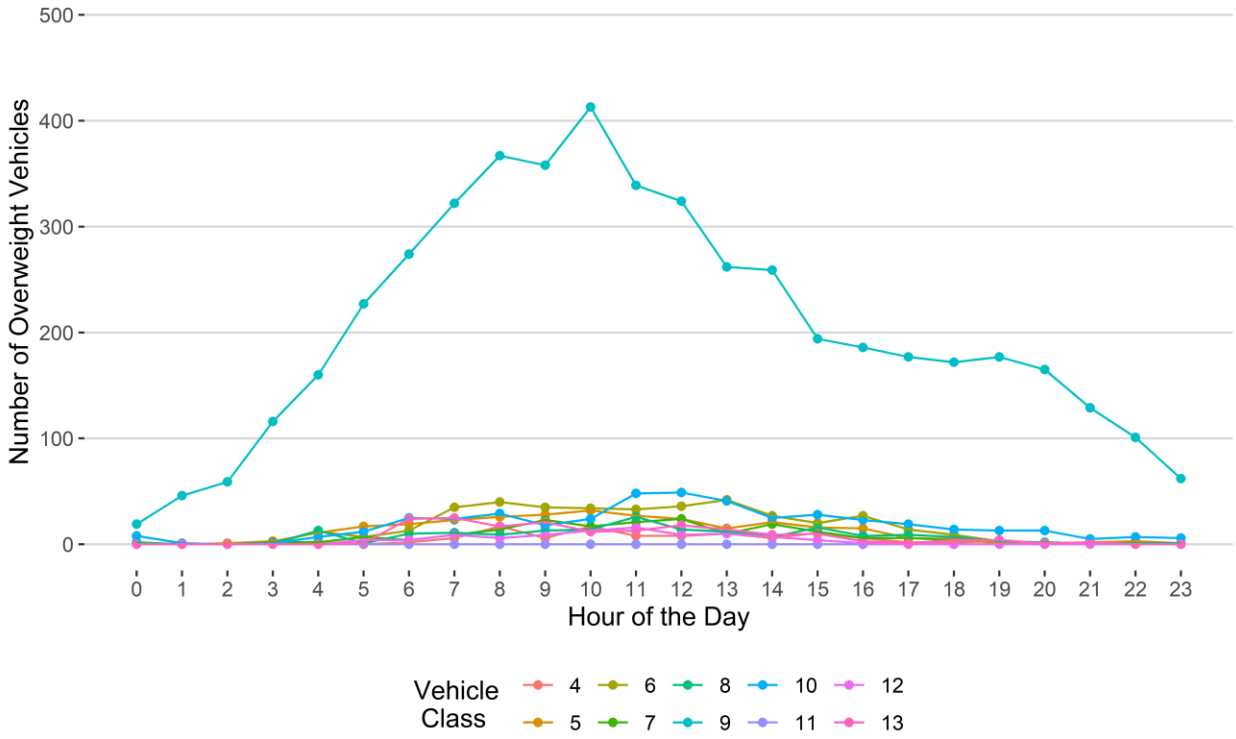


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

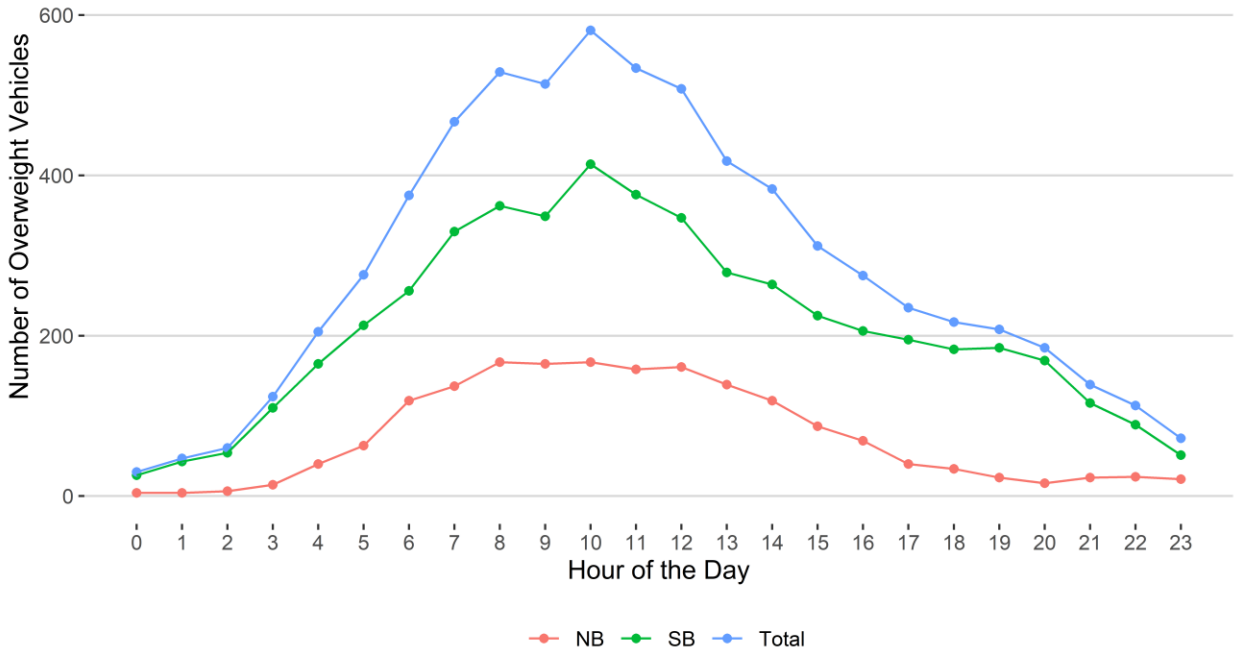
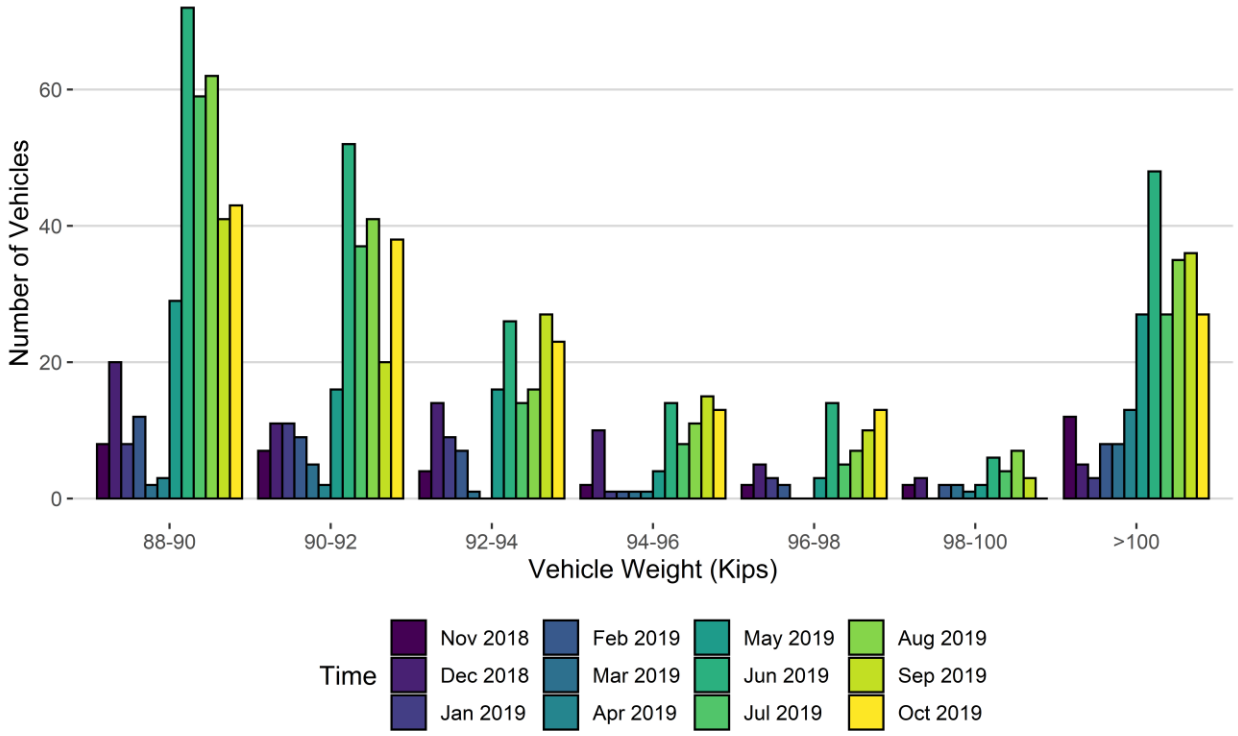
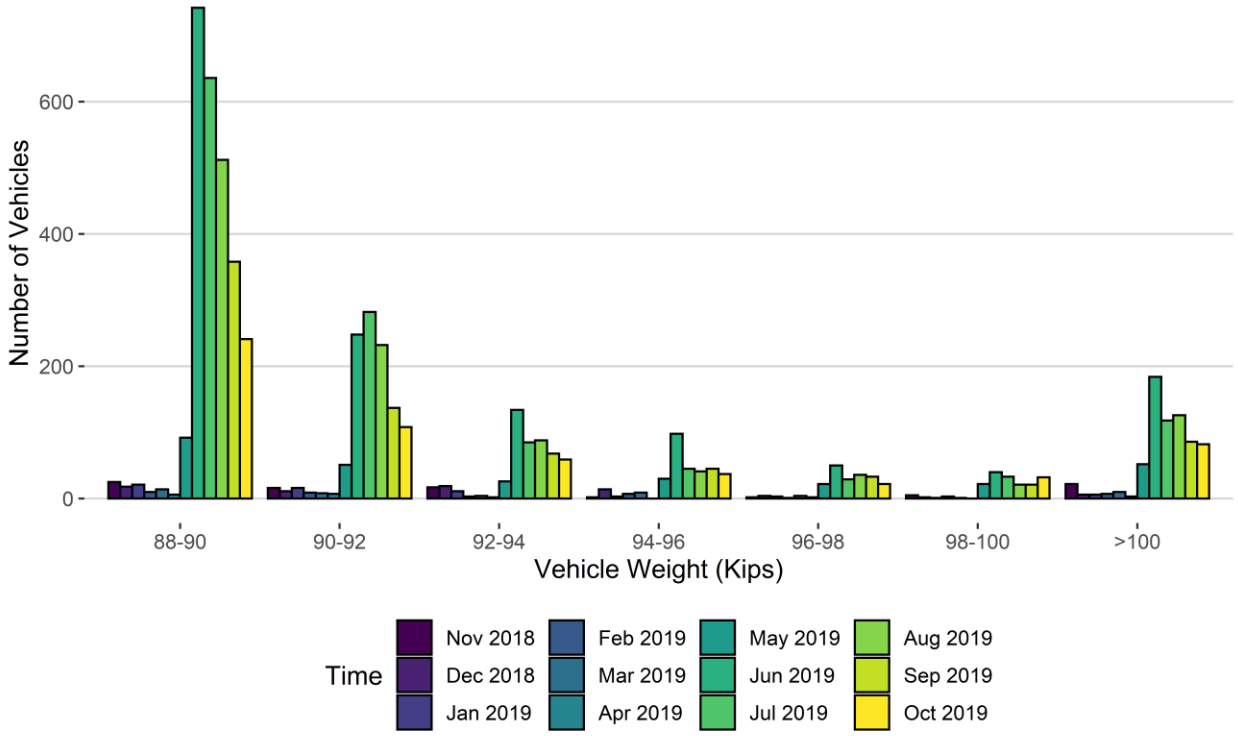


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*	*Oct 2019*
88-90	8	20	8	12	2	3	29	72	59	62	41	43
90-92	7	11	11	9	5	2	16	52	37	41	20	38
92-94	4	14	9	7	1	0	16	26	14	16	27	23
94-96	2	10	1	1	1	1	4	14	8	11	15	13
96-98	2	5	3	2	0	0	3	14	5	7	10	13
98-100	2	3	0	2	2	1	2	6	4	7	3	0
>100	12	5	3	8	8	13	27	48	27	35	36	27
Total	37	68	35	41	19	20	97	232	154	179	152	157

Figure 8 - Histogram of SB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*	*Oct 2019*
88-90	25	18	21	10	14	6	92	742	636	512	358	241
90-92	16	11	16	9	8	7	51	248	282	232	137	108
92-94	17	19	11	3	4	2	26	134	85	88	68	59
94-96	2	14	3	7	9	0	30	98	45	41	45	37
96-98	2	4	3	1	4	2	22	50	29	36	33	22
98-100	5	2	1	3	1	0	22	40	33	21	21	32
>100	22	6	6	7	10	3	52	184	118	126	86	82
Total	89	74	61	40	50	20	295	1496	1228	1056	748	581

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

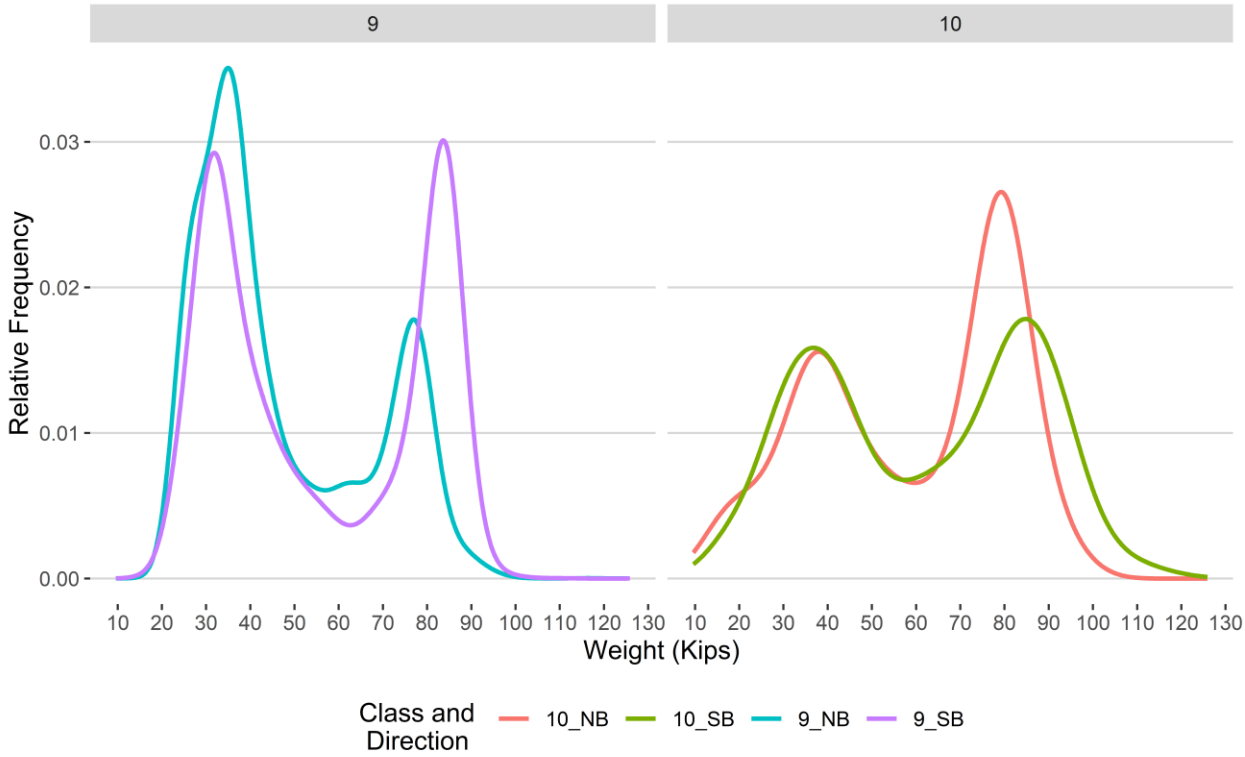


Figure 9 - Freight Percentage by Direction and Class

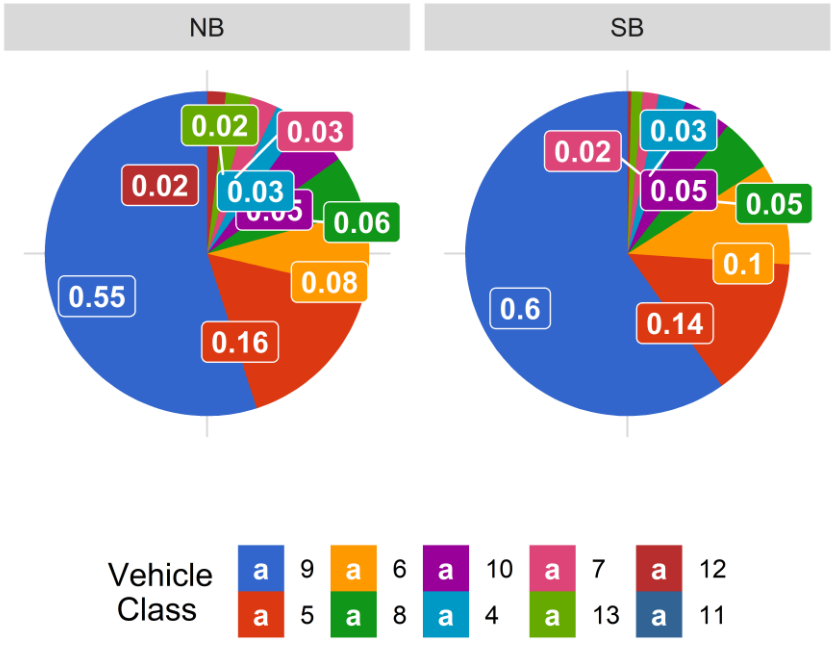


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

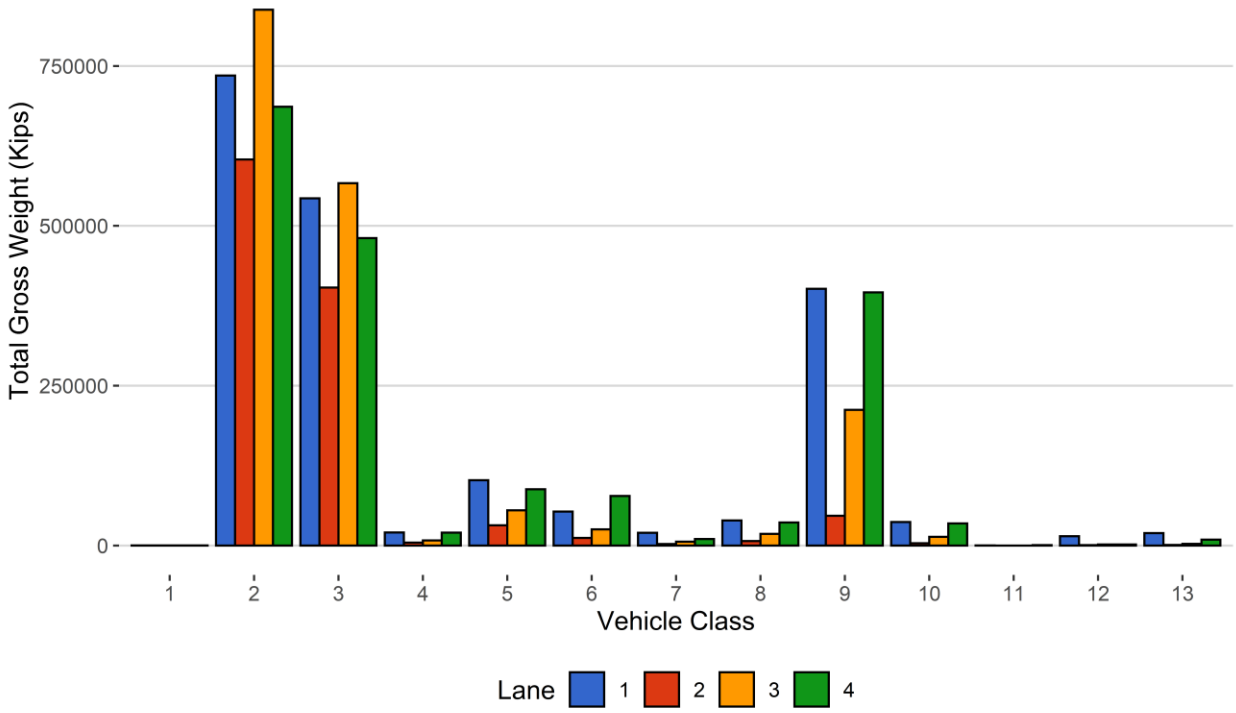


Figure 11 - Total Gross Vehicle Weight

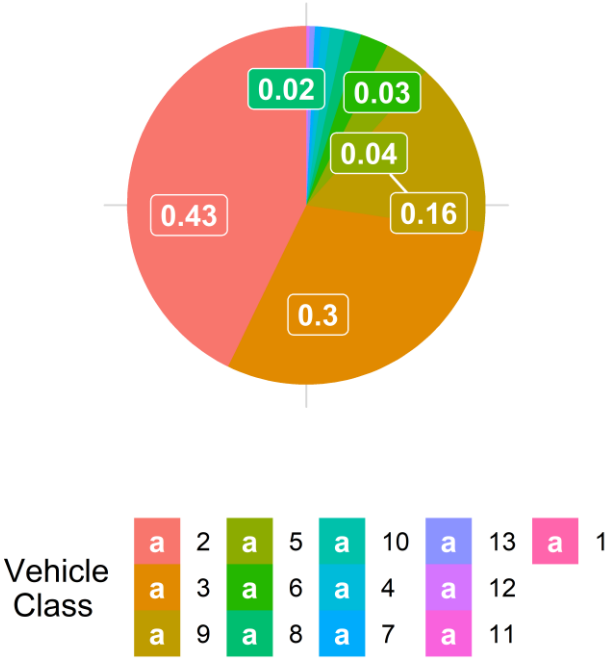


Figure 12 - Total ESALs by Class and Lane

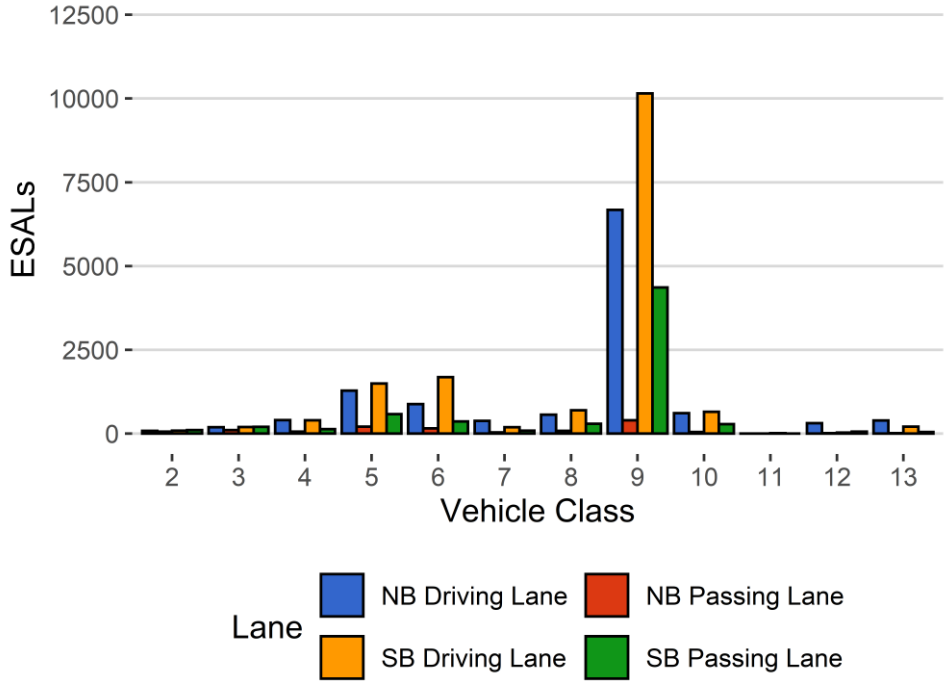


Figure 13 - ESALs by Class

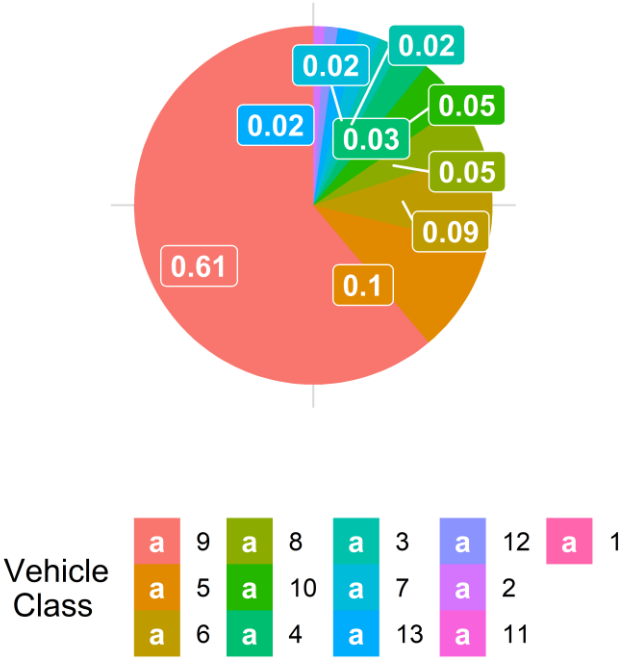


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*	*Lane 3 (Kips)*	*Front Axle +/- 9%*	*Lane 4 (kips)*	*Front Axle +/- 9%*
June 2019	10.72	0.00	10.57	0.00	11.19	0.00	11.79	0.00
July 2019	10.75	0.31	10.61	0.38	11.12	-0.62	11.91	1.04
August 2019	10.77	0.46	10.56	-0.06	10.92	-2.39	11.81	0.17
September 2019	10.71	-0.14	10.45	-1.16	11.04	-1.34	11.74	-0.41
October 2019	10.66	-0.61	10.19	-3.55	10.86	-2.91	11.56	-1.91

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	16	506	0	0	0
2	23742	735987	65.3	0	0
3	10856	336532	29.9	0	0
4	59	1831	0.2	105	1.5
5	632	19596	1.7	298	4.4
6	177	5490	0.5	392	5.8
7	21	645	0.1	185	2.7
8	107	3317	0.3	181	2.7
9	681	21126	1.9	4908	72.4
10	49	1504	0.1	440	6.5
11	0	15	0	0	0
12	9	266	0	92	1.4
13	13	389	0	179	2.6
TOTAL	**36361**	**1127204**	**100**	**6780**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-10-30	Wednesday	14:09:59	9	SB	4	125.88
2019-10-28	Monday	11:25:28	9	NB	1	125.18
2019-10-14	Monday	12:00:47	10	SB	3	120.51
2019-10-17	Thursday	10:25:19	9	NB	1	118.44
2019-10-04	Friday	23:06:19	9	NB	1	117.27
2019-10-29	Tuesday	06:28:41	9	NB	1	116.17
2019-10-02	Wednesday	18:56:58	10	SB	3	116.06
2019-10-22	Tuesday	13:50:06	10	SB	4	114.64
2019-10-25	Friday	14:38:51	10	SB	4	114.1
2019-10-22	Tuesday	11:40:23	9	NB	1	113.46

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	NB	15	863	127	14.7	23358	1620	6159
5	NB	8	9381	1256	13.4	124600	8947	29800
6	NB	19	2163	277	12.8	60452	4615	12309
7	NB	11.5	351	0	0	22251	0	9107
8	NB	31	1525	897	58.8	25236	20863	2884
9	NB	33	9491	2634	27.8	374366	73777	74043
10	NB	33.5	673	93	13.8	37931	2206	9250
11	NB	36.5	3	3	100	0	58	0
12	NB	36.5	215	1	0.5	15094	20	3641
13	NB	31.5	252	0	0	20253	0	6158
TOTAL	****	****	**24917**	**5288**	****	**703541**	****	**153351**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	SB	15	903	76	8.4	27053	995	7324
5	SB	8	9522	658	6.9	138030	4820	33559
6	SB	19	3133	210	6.7	99291	3541	21877
7	SB	11.5	271	0	0	16008	0	6446
8	SB	31	1675	767	45.8	37128	17259	4490
9	SB	33	10888	2788	25.6	527251	80804	129976
10	SB	33.5	778	137	17.6	44310	3724	11418
11	SB	36.5	11	0	0	676	0	137
12	SB	36.5	42	0	0	3114	0	790
13	SB	31.5	123	0	0	11670	0	3898
TOTAL	****	****	**27346**	**4636**	****	**904532**	****	**219915**
GRAND TOTAL	****	****	**52263**	**9924**	**353**	**1608073**	**223249**	**373267**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*
1	123	153	210	113	599	0
2	735073	603837	838029	686322	2863261	42.8
3	543085	403391	566709	480933	1994118	29.8
4	20355	4623	8027	20022	53026	0.8
5	102059	31488	54960	87890	276397	4.1
6	53117	11950	25314	77519	167900	2.5
7	19869	2381	5876	10132	38259	0.6
8	39185	6913	18297	36090	100486	1.5
9	401614	46529	212232	395823	1056198	15.8
10	36673	3464	13447	34587	88171	1.3
11	58	0	0	676	734	0
12	14504	610	1509	1604	18228	0.3
13	19494	759	2459	9211	31923	0.5
TOTAL	**1985209**	**1116099**	**1747070**	**1840921**	**6689299**	**100**
GVW/LANE	**29.68**	**16.68**	**26.12**	**27.52**	**100**	**0**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0	0	0.002
2	84	62	106	91	344	0.97	0.001
3	190	108	202	200	699	1.98	0.0043
4	405	58	132	401	996	2.82	1.13
5	1285	209	580	1497	3572	10.11	0.38
6	882	160	363	1686	3091	8.75	1.17
7	379	36	91	192	697	1.97	2.23
8	563	80	296	695	1634	4.63	1.02
9	6679	401	4360	10151	21591	61.13	2.12
10	614	46	285	651	1595	4.52	2.19
11	0	0	0	15	15	0.04	1.68
12	314	14	60	31	418	1.18	3.16
13	392	15	50	210	667	1.89	3.47
TOTAL	**11787**	**1189**	**6524**	**15820**	**35319**	**100**	**19**
ESALS/LANE	**33.4**	**3.4**	**18.5**	**44.8**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*	*Heavy Commercial Vehicles in Driving Lane %*	*Heavy Commercial Vehicles in Passing Lane %*
Nov 2018	980508	32684	1594	932691	95.1	47816.9	4.9	71.4	28.6
Dec 2018	921951	30732	1217	884226	95.9	37725.4	4.1	70.5	29.5
Jan 2019	912085	29422	1247	873418	95.8	38667.4	4.2	72	28
Feb 2019	795365	28406	1230	760938	95.7	34426.8	4.3	67	33
Mar 2019	973223	31394	1336	931796	95.7	41427.3	4.3	71.7	28.3
Apr 2019	1019560	33985	1544	973238	95.5	46322.3	4.5	72.1	27.9
May 2019	1118314	36375	1686	1066053	95.3	52260.7	4.7	71.6	28.4
Jun 2019	1096822	36561	1744	1044498	95.2	52323.8	4.8	70.1	29.9
Jul 2019	1100654	35362	1785	1045333	95	55321.1	5	71.7	28.3
Aug 2019	1121913	36075	1861	1064211	94.9	57701.6	5.1	72.4	27.6
Sep 2019	1078795	36258	1805	1024635	95	54159.7	5	72.2	27.8
Oct 2019	1127204	36288	1748	1073024	95.2	54179.9	4.8	70.7	29.3
TOTAL	**12246394**	**–**	**–**	**11674061**	**–**	**572333**	**–**	**–**	**–**
AVERAGE	**1020533**	**33628**	**1566**	**972838**	**95**	**47694**	**5**	**71**	**29**

###ESALs

Month	*ESALS NB Passing Lane*	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*ESALS SB Passing Lane*	*Total ESALS*	*Driving Lane ESALS %*	*Passing Lane ESALS %*	*Pavement Life Decrease Months*
Nov 2018	11820	925	3283	9678	25705	84	16	0.7
Dec 2018	9672	743	2777	6999	20190	83	17	2.8
Jan 2019	8504	642	2895	6695	18736	81	19	1.3
Feb 2019	7396	843	2850	4522	15611	76	24	1.9
Mar 2019	8913	920	2731	6292	18856	81	19	0.5

Apr 2019	8652	896	2921	6854	19322	80	20	0.1
May 2019	10529	1103	5184	12002	28819	78	22	6.2
Jun 2019	28564	2771	13156	27126	71617	78	22	2.9
Jul 2019	17750	1504	6355	15850	41459	81	19	3.6
Aug 2019	19834	1591	6030	16437	43893	83	17	3.7
Sep 2019	14251	1288	6245	15698	37482	80	20	16.3
Oct 2019	12262	1193	6548	15842	35845	78	22	11.8
TOTAL	**158147**	**14416**	**60975**	**143996**	**377535**	**–**	**–**	**–**
AVERAGE	**13179**	**1201**	**5081**	**12000**	**31461**	**80**	**20**	**4**

###Gross Vehicle Weight

Month	*GVW NB Passing Lane*	*GVW NB Driving Lane*	*GVW SB Passing Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Nov 18	1807476	940472	1377348	1453973	5579269
Dec 18	1696068	847600	1282320	1192264	5018252
Jan 19	1596048	784003	1204798	1160173	4745021
Feb 19	1387374	715290	1084749	864793	4052206
Mar 19	1654804	918271	1249463	1251819	5074356
Apr 19	1746072	946867	1329617	1290655	5313211
May 19	1895521	1089661	1663992	1664481	6313656
Jun 19	4148155	2426300	3405678	3123961	13104094
Jul 19	2179409	1266094	1670241	1741373	6857117
Aug 19	2270498	1248079	1680800	1830923	7030299
Sep 19	2061588	1110530	1638803	1740677	6551598
Oct 19	1989344	1116571	1747850	1841995	6695761
TOTAL	**24432356**	**13409739**	**19335659**	**19157086**	**76334840**
AVERAGE	**2036030**	**1117478**	**1611305**	**1596424**	**6361237**

###Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Nov 2018	3672	0.4	7.8	127	42
Dec 2018	2606	0.3	6.9	144	17
Jan 2019	1949	0.2	5.1	96	10
Feb 2019	1628	0.2	4.7	81	20
Mar 2019	1385	0.1	3.4	70	22
Apr 2019	1064	0.1	2.3	40	17
May 2019	4468	0.4	8.8	393	103
Jun 2019	14060	0.7	13.9	1736	282
Jul 2019	8530	0.8	15.7	1384	182

Aug 2019	9199	0.8	16.2	1236	189
Sep 2019	7237	0.7	13.6	900	146
Oct 2019	6807	0.6	12.9	738	141
TOTAL	**62605**	**–**	**–**	**6945**	**1171**
AVERAGE	**5217.1**	**0.4**	**9.3**	**578.8**	**97.6**

###Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Nov 2018	157880	147600	305480	51.7	48.3
Dec 2018	125562	112167	237729	52.8	47.2
Jan 2019	114896	109750	224646	51.1	48.9
Feb 2019	102376	83792	186168	55	45
Mar 2019	125458	111529	236987	52.9	47.1
Apr 2019	129728	127691	257419	50.4	49.6
May 2019	145149	190653	335802	43.2	56.8
Jun 2019	376690	385390	762081	49.4	50.6
Jul 2019	217482	209237	426719	51	49
Aug 2019	238156	208899	447055	53.3	46.7
Sep 2019	182005	210354	392359	46.4	53.6
Oct 2019	153351	219915	373267	41.1	58.9
TOTAL	**2068734**	**2116977**	**4185712**	**–**	**–**
AVERAGE	**172394.5**	**176414.8**	**348809.3**	**49.9**	**50.1**